SECTION 894
HIGHWAY SIGNS AND POSTS

894.01 SIGN BACKING MATERIAL.

A. **Materials.**

1. **Flat Sheet Aluminum.** Flat sheet aluminum shall be an alloy meeting ASTM B-209 alloy 6061-T6, or 5052-H38 with mill finish.

2. **Extruded Aluminum Panels.** Extruded Aluminum Panels shall meet ASTM B-221 Alloy 6063-T6. The panels shall be furnished in 12-inch and 6-inch sections as shown on the Plans. All panels shall be flat and straight within commercial tolerances established by the aluminum industry.

B. **Shop Surface Preparation and Processing.** All sign backing shall be clean and free of rust, white rust, oil, and dirt. The holes shall be shop drilled to the sizes and at locations shown in the Contract. Holes required in the sign backing shall not be field drilled.

1. **Degreasing.** The extruded aluminum panels shall be rubbed with a clean white cloth after degreasing and if any sticky material shows up on the cloth, the panels shall be degreased again. All aluminum sign backing shall be degreased by one of the following methods:

   a. **Vapor Degreasing.** Aluminum materials shall be immersed in a saturated vapor of trichloroethylene. Trademark printing shall be removed with a lacquer thinner or a controlled alkaline cleaning system.

   b. **Alkaline Degreasing.** The aluminum shall be immersed in an alkaline solution controlled and titrated according to the solution manufacturer's recommendations. The immersion time shall be dependent upon the gauge of the metal and the amount of soil to be removed.

2. **Etching.** All sheet aluminum shall be etched after degreasing. Extruded aluminum panels which have a roughened surface texture suitable for paint or sheeting shall not be etched after degreasing unless the Engineer determines the panels are unsuitable. Etching shall be performed by one of the following methods:

   a. **Acid Etch.** The aluminum shall be etched in a 6% to 8% solution of phosphoric acid at 100°F., or a proprietary acid etching solution. It shall be rinsed after etching with cold running water followed by a hot water rinse.

   b. **Alkaline Etch.** The aluminum shall be etched in an alkaline solution controlled by titration. The length of time the aluminum is etched and the

temperature and concentration of the solution shall comply with the solution manufacturer's instructions. The aluminum shall be well rinsed after etching. Smut on the aluminum shall be removed with an acidic chromium solution recommended by the solution manufacturer and then well rinsed.

3. **Coating.** Aluminum panels that have not had reflective sheeting applied for several days or longer, after being etched, shall be treated with a light, tightly adherent chromate conversion coating before applying the reflective sheeting. The chromate conversion coating shall be free of powdery residue and shall range in color from a silvery iridescence to a pale yellow. The coating shall meet ASTM B-449, Class 2, 10–35 milligrams/square foot with a median of 25 milligrams/square foot as an optimum coating weight.

4. **Drying.** All sign backing material shall be dried with forced hot air after preparation and processing.

894.02 RETROREFLECTIVE SHEETING MATERIALS.

A. **General.** The retroreflective sheeting stored under normal conditions shall be used within one year from the manufactured date. The packaging cartons or roll goods shall be marked with the manufacturer's lot numbers and manufacture date.

The surface of the barricade rails, drums, or cones shall be treated as recommended by the sheeting manufacturer before applying the reflective sheeting.

Type III C reflective sheeting shall have an identification symbol on the surface to differentiate it from other types of sheeting. The identification symbol shall not interfere with the function of the sheeting, but shall be visible to inspectors day or night without the use of special devices. The symbol shall be in a repeat pattern such that any 4-inch by 8-inch or 5-inch by 5-inch piece of the sheeting contains at least one full symbol.

The durability of the retroreflective sheeting shall be substantiated by the following accelerated weathering tests:

1. **Accelerated Outdoor Test.** When the retroreflective sheeting is processed and applied according to recommended procedures, the sheeting shall be weather-resistant, resistant to dirt and fungus accumulation, and following cleaning, shall show no discoloration, cracking, crazing, blistering, or dimensional change, and have not less than 50% for Type II and IV sheeting and not less than 80% for Type III A sheeting of the specified minimum brightness values shown in AASHTO M-268 measured at an observation angle of 0.2° and an entrance angle of –4° when exposed to accelerated weathering for 30 months, south-facing, unprotected at 45°.

2. **Accelerated Machine Test.** The retroreflective sheeting shall meet the artificial weathering requirements of AASHTO M-268 measured at an observation angle of 0.2° and an entrance angle of –4°.

The Contractor shall furnish written evidence showing conformance with one of the following:

1. The accelerated outdoor test, done in North Dakota or in a state located at lower latitudes, or

2. The accelerated machine test and 3 years of performance in the field with no problems.

The Contractor shall secure from the manufacturer all warranties and guarantees with respect to materials, parts, workmanship, or performance which the products covered by the proposal bear, and include these warranties and guarantees with the certification.

B. **Type II and III A Retroreflective Sheeting Material.** Type II and III A retroreflective sheeting shall meet AASHTO M-268 and the following:

Processed retroreflective sheeting shall be applied to approved sign base material and cleaned according to manufacturer's recommendations for use on traffic control signs. The Contractor shall furnish a written assurance that the sheeting will meet the requirements of the following tables throughout the satisfactory performance life and be effective for its intended purpose when viewed from a vehicle.

TYPE II RETROREFLECTIVE SHEETING

Sheeting Type and Color	**Average Minimum Candelas per foot Candle per sq. ft. at 0.2º divergence and –4º incidence***	**Satisfactory Performance Life**
Silver-White #1	30.0	5 years
Silver-White #2	36.0	5 years
Yellow	20.0	5 years
Red	5.0	5 years
Blue	2.0	5 years
Green	3.0	5 years
Orange	10.0	5 years
Brown	0.4	5 years

TYPE III A RETROREFLECTIVE SHEETING

Sheeting Type and Color	Average Minimum Candelas per foot Candle per sq. ft. at 0.2º divergence and –4º incidence*	Satisfactory Performance Life
Silver-White	200.0	10 years
Green	36.0	10 years
Yellow	136.0	10 years
Red	36.0	10 years
Orange	80.0	3 years
Blue	16.0	10 years

*Candlepower measurement shall be made, following sign cleaning, in accordance with procedure recommended by the sheeting manufacturer.

C. **Type III B Retroreflective Sheeting.** Type III B retroreflective sheeting shall consist of optical lens elements adhered to a synthetic resin and encapsulated by a flexible transparent plastic that has a smooth outer surface. The sheeting shall have a precoated adhesive protected by an easily removable liner. This sheeting is intended for use on rigid substrate signs and barricades used in the construction work zone. Type III B retroreflective sheeting shall meet AASHTO M-268 and the following:

The Contractor shall furnish a written assurance that the sheeting will meet the requirements of the following table throughout the satisfactory performance life and be effective for its intended purpose when viewed from a vehicle:

TYPE III B RETROREFLECTIVE SHEETING

Sheeting Type and Color	Average Minimum Candelas per foot Candle per sq. ft. at 0.2º divergence and –4º incidence*	Satisfactory Performance Life
White	200	3 years
Yellow	136	3 years
Orange	80	3 years
Prestriped Barricade	200/80	3 years

*Candlepower measurement shall be made, following sign cleaning, in accordance with procedure recommended by the sheeting manufacturer.

The impact resistance shall be tested on reflective sheeting, applied according to the manufacturer's recommendations to a cleaned, etched aluminum panel of Alloy 6061 T 6, 0.063 inches by 3 inches by 5 inches and conditioned for 24 hours at 0°C.

The sheeting to be tested for flexibility shall be conditioned for 24 hours at 0°C.

D. **Type III C Retroreflective Sheeting.** Type III C retroreflective sheeting shall consist of optical lens elements adhered to a synthetic resin and encapsulated by a

flexible transparent plastic that has a smooth outer surface. The sheeting shall have a precoated adhesive protected by an easily removable liner. This sheeting is intended for use on plastic reboundable devices such as drums and flexible delineation posts. Type III C retroreflective sheeting shall meet the weathering requirements of AASHTO M-268, Type IV and the following:

The Contractor shall furnish a written assurance that the sheeting will meet the requirement of the following table and be effective for its intended purpose when viewed from a vehicle.

TYPE III C RETROREFLECTIVE SHEETING

Average minimum Candeles per foot candle per square foot.

Observation Angle	Entrance Angle	White	Yellow	Orange
0.2°	–4°	250	170	100
0.2°	+30°	150	100	60
0.5°	–4°	95	62	30
0.5°	+30°	65	45	25

The impact-resistant aluminum panel shall be the same as Type III B reflective sheeting.

The impact resistance shall be tested on a Gardner Variable Impact Tester, I6-1120 using a 4-pound weight with a 5/8-inch rounded tip dropped from a 100 inch-pound setting.

Type III C reflective sheeting performance on reboundable plastic substrates shall be measured using the following test:

The device shall be impacted 3 times by a 4,000 pound vehicle, with a 20-inch bumper, at 40 mph. Each impact shall be a direct hit (glancing blows will not be allowed). After the impacts, the reflective sheeting shall be considered performing satisfactorily when no loss of sheeting results and there is no visible change in day and night performance (when viewed from 500 feet).

The sheeting to be tested for flexibility shall be conditioned for 24 hours at 0°C.

E. **Type IV Reflective Sheeting.** The Type IV reflective sheeting shall consist of high-gloss transparent ultra-violet light-stabilized polyester film bonded to a layer of polyester cube corner prisms with not less than 40,000 prisms per square inch meeting AASHTO M-268 and the following:

1. **Type IV, Class 1 Reflective Sheeting.** The backing for the polyester sheeting used on barricade rails, drums, and traffic cones shall be an opaque-white plasticized polyester film not less than 0.004 inch thick with an adhesive backing meeting AASHTO M-268, Class 1.

2. **Flexible Rollup Sign, Non-Adhesive Backing Fabric.** The polyester sheeting on the flexible rollup portable signs shall be coated on both sides with orange pigment polyester and shall meet the following specifications:

Base Fabric	
Fiber	1,000 denier polyester
Weight	3 ounces/square yard
Fabric Count	10 warp, 10 fill
Coated Fabric	
Total Weight	14 ± 1/2 ounces/square yard
Type of Coating	PVC
Color	Orange
Distribution	60 face, 40 back

Mechanical Properties		**Federal Standard 191 Method**
Tensile Strength	Warp 250, Fill 200	5100
Tear Strength	Warp 85, Fill 95	5134.1
Low Temperature	–65°F.	
High Temperature Continuous	+180°F.	
Abrasion Resistance (Taber)	1700 Cycles	5306
Flame Resistance	California Fire Marshall Approved Reg. No. F 102.4	

F. **Wide Angle Prismatic Reflective Sheeting.** The sheeting shall consist of prismatic lenses formed in a transparent synthetic resin, sealed, and backed with an aggressive pressure sensitive adhesive protected by a removable liner. The sheeting shall have a smooth surface with a distinctive interlocking diamond seal pattern and orientation marks visible on the face.

MINIMUM COEFFICIENT OF RETROREFLECTION
(Candelas per footcandle per square foot)
90° Rotation Angle

Observation Angle (Deg.)	**Entrance Angle (Deg.)**	**White**	**Orange**
0.2	–4	800	300
0.2	+30	400	150
0.2	+50	120	50
0.5	–4	200	100
0.5	+30	100	50
0.5	+50	40	20

Daytime color shall conform to the table shown below. Color of sheeting mounted on aluminum test panels shall be determined instrumentally in accordance with ASTM E 1164. Values shall be determined on a HunterLab Labscan 6000 0/45 Spectrocolorimeter with option CMR 559. Computations shall be done in accordance with ASTM E 308 for the 2° observer.

COLOR SPECIFICATION LIMITS* (DAYTIME)

Color	1		2		3		4		Reflectance Limit Y (%)	
	x	y	x	y	x	y	x	y	min.	max.
White	.305	.305	.355	.355	.335	.375	.285	.325	40	–
Orange	.583	.416	.523	.397	.560	.360	.631	.369	12	30

*The 4 pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D65.

The sheeting shall show no cracking outside the impact area when the face of the panel is subjected to an impact of 100 inch-pounds, using a weight with a 5/8" diameter rounded tip dropped from a height necessary to generate an impact of 100 inch-pounds, at temperatures of both 32°F. and 72°F.

The impact-resistant aluminum panel shall be the same as required for Type III B reflective sheeting.

The Retroreflective Sheeting shall be processed and applied to aluminum sign blank materials in accordance with the sheeting manufacturer's instructions. The sheeting shall perform effectively for 3 years. If, within 3 years from the date of acceptance, the sheeting has deteriorated due to natural causes to the extent that (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day or night driving conditions by a driver with normal vision; or (2) the coefficient of retroreflection, after cleaning, is less than 400 for white and 150 for orange when measured at 0.2° observation and –4° entrance at 90° rotation; new sheeting will be furnished and installed by the Contractor.

G. **Fluorescent Orange Wide Angle Prismatic Retroreflective Sheeting.** The sheeting shall consist of prismatic lenses formed in a transparent fluorescent orange synthetic resin, sealed, and backed with an aggressive pressure sensitive adhesive protected by a removable liner. The sheeting shall have a smooth surface with distinctive interlocking diamond seal pattern and orientation marks visible from the face.

MINIMUM COEFFICIENT OF RETROREFLECTION
(Candelas per footcandle per square foot)
905 **Rotation Angle**

Observation Angle (Deg.)	Entrance Angle (Deg.)	Orange
0.2	–4	200
0.2	+30	120
0.2	+50	50
0.5	–4	80
0.5	+30	50
0.5	+50	20

Daytime color and maximum spectral radiance factor (peak reflectance) shall be determined in accordance with ASTM E 991 using a HunterLab Labscan 6000 0/45.

COLOR SPECIFICATION LIMITS (DAYTIME)

Color	1		2		3		4		**Reflectance Limit Y (%)**	
	x	y	x	y	x	y	x	y	min.	max.
Orange (new)	.583	.416	.523	.396	.560	.360	.631	.369	30	–
Orange (weathered)	.583	.416	.523	.396	.560	.360	.631	.369	20	45

Nighttime color shall be determined in accordance with ASTM E 811 and calculated in the u', v' coordinate system in accordance with ASTM E 308. Sheeting shall be measured at 0.33° observation and –4° entrance at 90° rotation.

COLOR SPECIFICATION LIMITS (NIGHTTIME)

Color	1		2		3		4	
	u'	v'	u'	v'	u'	v'	u'	v'
Orange (new and weathered)	.400	.540	.475	.529	.448	.522	.372	.534

The sheeting impact resistance requirements shall be the same as in Section 894.02 F.

The impact-resistant aluminum panel shall be the same as that required in Section 894.02 F.

The field performance requirements shall be the same as specified in Section 894.02 F., except that coefficient of refraction for the fluorescent sheeting can be no lower than 100.

894.03 PIGMENTED PLASTIC FILM, PRESSURE-SENSITIVE ADHESIVE.

A. **Description.** This material shall be flexible, pigmented plastic film completely precoated with a pressure-sensitive adhesive. The adhesive shall be protected by a treated paper liner which shall be removable without soaking in water or other solvents. The material shall be available in colors listed in Section 894.03 B.7.

B. **Material Requirements.** Material requirements shall be as follows:

1. **Thickness.** The thickness of the plastic film with adhesives shall be a minimum of 0.003 inch and a maximum of 0.0045 inch.

2. **Film.** The unapplied and applied film shall be readily processed and shall ensure adequate adhesion with process or printed inks recommended by the manufacturer.

3. **Flexibility.** The material shall be sufficiently flexible to permit application over and conformance to moderately-contoured surfaces.

4. **Gloss.** The film shall have a minimum initial 60° gloss value of 35 when tested according to ASTM D-523, measuring at least 3 portions of the film to obtain uniformity.

5. **Adhesive.** The precoated adhesive shall form a durable bond to smooth, clean, corrosion-resistant, and weather-resistant surface; shall be of uniform thickness; shall be noncorrosive to applied surfaces; and shall have no staining effect on the film. The adhesive shall adhere securely at temperatures of –30°F. to +200°F.; shall not crack, chip, or peel voluntarily; nor shall it be removed from the panel in one piece without the aid of a tool.

6. **Sunlight Resistance.** There shall be no effect on the adhesive tack or performance following exposure of the adhesive face under a new General Electric RS Sunlamp for a period of 6 hours at a distance of 8 inches.

7. **Exterior Exposure.** The unprocessed material shall withstand the years of exposure, listed below by color, in a vertical, south facing exterior exposure in Texas. During the exposure, the unprocessed material shall show no appreciable discoloration, cracking, crazing, blistering, delamination, or loss of adhesion. A slight amount of chalking is permissible. The Contractor shall furnish a written assurance from the manufacturer that the sheeting will meet the requirements of the following table and be effective for its intended purpose when viewed from a vehicle, throughout the satisfactory performance life:

Color	Satisfactory Performance Life
White	7 years
Black	7 years
Yellow	5 years
Aluminum	5 years
Insignia Blue	5 years
Transparent	5 years
Red	3 years
Gold	3 years

The Contractor shall secure from the manufacturer all warranties and guarantees with respect to materials, parts, workmanship, or performance which the products covered by the proposal bear, and include these warranties and guarantees with the certification.

8. **Fungus Growth.** The film shall not support fungus growth.

9. **Plastic Lettering.** Plastic lettering film as furnished in rolls, sheets, or letters shall be free from ragged edges, cracks, blisters, streaks, foreign matter, or

other surface imperfections which would make it unsuitable for usage. The plastic lettering film shall be capable of being readily cut with scissors, knives, blades, or shears without cracking, crazing, checking, or flaking.

894.04 LETTERS, NUMERALS, SYMBOLS, AND BORDERS FOR PANEL SIGNS.

A. **General.** All letters, numerals, symbols, and borders shall meet the requirements shown in the Contract and the MUTCD.

All letters, numerals, symbols, and borders shall have a regular outline and be clean-cut and sharp. All letters, numerals, and symbols shall have a continuous stroke and border. In special cases, symbols may have a broken stroke and border, provided they do not exceed more than 2 increments and that they are necessary for manufacturer's fabrication.

Blind rivets used for mounting shall conform to the Plans and shall extend past the back of the sign backing for a minimum distance of 1/8 inch. They shall be made of nonrust material.

B. **Demountable Reflectorized Cutout Letters, Numerals, Symbols, and Borders.** Demountable reflectorized cutout type letters, numerals, symbols, and borders shall consist of adhesive-coated reflective sheeting permanently adhered to a flat sheet aluminum backing. Type III and IV reflective sheeting meeting Section 894.02 shall be used.

The reflective sheeting shall be applied to the properly-prepared aluminum with the equipment and in the manner prescribed by the sheeting manufacturer.

Letters, numerals, symbols, and border backing shall be aluminum alloy meeting ASTM B-209, Alloy 6061-T6 or 5052-H38 with mill finish and of the thickness shown on the Plans. Aluminum backing shall be properly degreased and etched as specified in Section 894.01 B.

Mounting holes shall be uniformly spaced around the letters or characters and shall have the edge clearance shown in the Contract. The spacing shall be determined by the character size and shape. Mounting holes shall be spaced no more than 8 inches on centers, except for characters of 8 inches height or less. For characters 8 inches high or less, the maximum spacing of mounting holes shall be 4 inches. Mounting holes shall be drilled by the manufacturer.

Each letter, numeral, symbol, and border shall be offset, unless otherwise specified, as shown on the Plans with aluminum shim spacers meeting ASTM B-221, Alloy 2024. Finish of the letters, numerals, symbols, and borders shall be done with material and in the manner specified by the manufacturer of the reflective sheeting.

C. **Demountable Cutout Letters, Symbols, Numerals, and Borders Using Acrylic Plastic Reflectors.** Demountable cutout letters, symbols, numerals, and borders shall consist of acrylic plastic prismatic reflectors supported by embossed aluminum frames.

1. **Acrylic Plastic Reflectors.** The reflectors shall meet the following:

a. **Material.** The material shall be an acrylic plastic made from methyl methacrylate. The reflector shall have a clean, transparent face (lens). The back shall be opaque and shall be made of identical material to the lens. It shall be fused to the lens around the entire perimeter to form a permanent seal against dust, water, and water vapor.

The lens shall have a smooth front surface free of indentation or projection other than identification. The rear surface of the lens shall have a prismatic configuration to effect a total internal reflection of light. The lens shall be colorless.

b. **Optical Requirements.** The optical requirements shall be tested as specified in Section 894.06 B.2.c. with the following minimum values:

Observation Angle Degrees	Entrance Angle Degrees	Specific Brightness Candelas/Ft. Candle/Sq. Ft.
0.2°	0°	3.0
0.2°	20°	1.2

c. **Durability.** The reflectors shall conform to Section 894.06 B.2.d.

d. **Corrosion.** The assembled cutout letter, symbol, or accessory shall withstand the combined corrosion test of ASTM B-117.

2. **Embossed Aluminum Frames.** All letters, numerals, and symbols shall be fabricated from aluminum alloy meeting ASTM B-209, Alloy 3003 sheet aluminum. Border strips shall be fabricated from aluminum alloy meeting ASTM B-211, Alloy 6061-T6 sheet aluminum of the thickness shown on the Plans. Fabrication requirements are as follows:

Mounting holes shall be provided within frames to permit the use of nonrust screw, rivets, or other common nonrust fasteners.

The size and spacing of reflector holes shall afford maximum night legibility and visibility to the finished cutout figures.

After metal fabrication has been completed, the finish process shall be as follows:

Aluminum frames shall be degreased, etched, and given an alkaline chrome surface treatment and then rinsed and dried before prefiring.

The pre-prepared frames shall be sprayed with enamel slip consisting of a finely ground water-suspended glass frit, pigment, suspension agent, and opacifiers. Firing temperatures range from 930°F. to 1,010°F. depending on frit formulation, alloy, etc. Oven temperature shall be controlled ± 1°F. Temperatures for baking on enamel shall be as specified by the manufacturer of the enamel slip.

D. **Direct Applied Type III A and III B Reflective Sheeting Letters, Numerals, Symbols, and Borders.**

1. **General.** The letters, numerals, symbols, and border shall consist of adhesive-coated, pressure-sensitive reflective sheeting meeting Section 894.02. The material used for fabrication of letters, numerals, symbols, borders, and route markers shall be sampled and tested as specified for other reflective materials.

2. **Fabrication.** Letters, numerals, symbols, and borders shall be cut from reflective sheeting and shall have smooth regular outline, free from ragged or torn edges. Letters, numerals, and symbols having interior or exterior corners shall have these corners cut with a smooth 3/16 inch ± 1/16 inch radius. Border corners and strips shall have no corner radius. Route markers used in conjunction with direct-applied letter shall be applied to 0.040 aluminum backing and shall be attached with blind rivets or other common nonrust fasteners. Fasteners shall be placed a maximum of 6 inches on center around the perimeter of the shield. The reflective sheeting shall be of the same type specified for the letters. All sheeting, numerals, symbols, and borders shall show careful workmanship and shall be of regular outline.

894.05 POSTS AND HARDWARE FOR SIGNS.

A. **Hardware for Signs.**

1. **General.** All aluminum bolts, nuts, U-bolts, lockwashers, and washers shall be given at least a 0.002-inch anodic coating and chromate seal. All steel bolts, nuts, U-bolts, lockwashers, and washers shall be galvanized steel meeting ASTM A-153.

   Use of substitute alloys in lieu of the alloy specified for various items of "Hardware for Signs" may be approved by the Engineer upon submission of documented evidence that the proposed substitute alloy has applicable qualities equal to or superior to the designated alloy.

2. **Bolts.** Aluminum panel bolts, etc., shall be fabricated of aluminum alloy meeting ASTM B-211, Alloy 2024-T4 or 6061-T6.

   Steel panel bolts, machine bolts, etc., shall meet ASTM A-307.

3. **Nuts.** Aluminum nuts, hex nuts, vandal-resistant nuts shall be fabricated of aluminum alloy meeting ASTM B-211, Alloy 6061-T6.

   Steel hex nuts shall meet ASTM A-307.

   In lieu of using torque wrenches to obtain the required torques for fuse joints and slip base used in the breakaway system, the Torque Control Nut System may be used. This system shall provide automatic torque control, consistently-controlled preload, vibration resistance, high strength, easy installation, simple inspection, and resistance to weather effects.

   The torque control nut shall be designed to mate with standard high-strength bolts meeting ASTM A-325. The minimum stripping strength of the threads shall be equal to or shall exceed the strength level of the mating bolts.

   The self-locking quality of resistance to loosening shall meet the tests in Federal Specification MIL-N-25027 and shall be installed according to the manufacturer's recommendations.

4. **Washers.** Aluminum lockwashers shall be fabricated of aluminum alloy meeting ASTM B-209, Alloy 7075-T6.

   Aluminum flat washers shall be fabricated of aluminum alloy meeting ASTM B-209, Alloy 2024-T4.

   Steel lockwashers shall be fabricated of steel meeting ANSI B-27.1.

   Steel flat washers shall be fabricated of steel meeting ASTM A-307.

   Plastic washers shall be fabricated to the sheeting manufacturer's specifications.

5. **Stringers.** Aluminum stringers shall be fabricated to Plan dimensions and made of aluminum alloy meeting ASTM B-221, Alloy 6061-T6 or ASTM B-308, Alloy 6061-T6.

   Steel stringers shall be fabricated to Plan dimensions and made of steel meeting ASTM A-36.

6. **Aluminum Alloy Castings.** Brackets, post caps, and fuse plates may be either permanent mold castings or sand castings.

   Aluminum alloy permanent mold castings shall meet ASTM B-108, Alloy SG70A-F or SG80A-T6.

   Aluminum alloy sand castings shall meet ASTM B-26, Alloy SG70A-F or SG70A-T6.

7. **Steel Castings.** Brackets, post caps, and fuse plates shall meet AASHTO M-103, Grade 65-35.

8. **U-Bolts.** Aluminum U-bolts shall be fabricated of aluminum alloy meeting ASTM B-211, Alloy 2017-T4.

   Steel U-bolts shall be fabricated of steel meeting ASTM A-307.

9. **Anchor Bolts.** Anchor bolts, anchor studs, nuts, and washers shall be fabricated of steel meeting ASTM A-307 and meet AASHTO M-314 Grade 55 Mechanical requirements.

   All nuts, washers, and anchor studs shall be galvanized steel meeting ASTM A-153.

   The hex bar shall be tapped with U.S.S. Standard right thread, both ends, and made of steel meeting ASTM A-307.

10. A**ttachment Clip and Plate.** Attachment clip and plate for attachment of steel panels shall be fabricated as shown in the Contract, and made of steel meeting ASTM A-283 and galvanized in conformance to ASTM A-153.

11. **Fuse Joint Bolts.** Aluminum fuse plate bolts and washers shall be fabricated from aluminum meeting ASTM B-211, Alloy 2024-T4.

Steel fuse plate bolts and washers shall be fabricated from steel meeting ASTM A-325, and nuts shall be of the capacity to develop the bolt strength. Bolts, nuts, and washers shall be galvanized according to ASTM A-153.

12. **Breakaway Base Bolts.** All breakaway base bolts shall have bolts and washers fabricated from steel meeting ASTM A-325, and nuts shall be of the capacity to develop the bolt strength. Bolts, nuts, and washers shall be galvanized according to ASTM A-153.

B. **Posts.**

1. **General.** Tubular post size, length, and weight shall be as shown in the Contract for each type of sign.

   Welding on aluminum shall be done according to Section 5 and welding on galvanized steel shall be done according to Section 4 of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

   All markings on posts, signs, casting, etc., shall be removed after erection.

2. **Aluminum Tubular Posts and Accessories.**

Material	**Specification**
Drawn Seamless Tubes and Extruded Round or Square Tubes	ASTM B-210, Alloy 6061-T6 or ASTM B-241, Alloy 6061-T6
Extruded Structural Shapes	ASTM B-221, Alloy 6061-T6
Breakaway Bases	ASTM B-209, Alloy 6061-T6
Fuse Plates	ASTM B-209, Alloy 6061-T6
Fuse Plate Bolts and Washers	ASTM B-211, Alloy 2024-T4

3. **Steel (Galvanized) Posts and Accessories.**

Material	**Specification**
Standard Steel Pipe	AASHTO M-111, 270 Grade 36, and M-232
Breakaway Bases	AASHTO 270 Grade 36 and M-232
Fuse Plates	AASHTO 270 Grade 36 and M-232

4. **Square Steel Telescoping Tubular Posts.** Tubing shall be of the size and shape shown in the Contract and shall meet the following requirements:

   a. **Material.** Steel posts shall conform to the standard specifications for a Grade 55 hot rolled carbon sheet steel, structural quality, ASTM designation A570.

b. **Shape.** The cross section of the post shall be square tube formed of 12 gauge (.105 U.S.S. gauge) and 10 gauge (.135 U.S.S. gauge) steel, carefully rolled to size and shall be welded directly in the corner by high frequency resistance welding and externally scarfed to agree with corner radii.

c. **Finish.** Signposts shall be manufactured from hot-dipped galvanized steel conforming to ASTM specification A653, designation G90. The corner weld shall be zinc coated after scarfing operation. The steel shall be coated with a chromate conversion coating and a clear organic polymer topcoat. Both the interior and the exterior of the post shall be galvanized.

d. **Cross Section.** Perforated sign posts shall be one or more of the following sizes:

Size	U.S.S. Gauge	Weight (lbs./foot)
1 1/2" × 1 1/2"	12	1.70
2" × 2"	12	2.42
2 1/4" × 2 1/4"	12	2.77
2 1/2" × 2 1/2"	12	3.14
2 3/16" × 2 3/16"	10	3.43
2 1/2" × 2 1/2"	10	4.01

e. **Holes.** Holes shall be 7/16 ± 1/64 inches in diameter on one (1) inch centers on all four sides down the entire length of the post. The holes shall be on centerline of each side in true alignment and opposite each other directly and diagonally. All metal shall be removed from the punched holes.

f. **Length.** The length of each post shall have a permissible length tolerance of ±1/4 inch.

g. **Telescoping Properties.** The finished posts shall be straight and have a smooth, uniform finish. It shall be possible to telescope all consecutive sizes of square tubes freely and for not less than ten feet of their length without the necessity of matching any particular face to any other face. All holes and ends shall be free from burrs and ends shall be cut square.

h. **Tolerances.**

(1) Tolerances on outside sizes:

Nominal Outside Dimensions	Outside Tolerances at All Sides at Corners
1 1/2" × 1 1/2"	±.006"
2" × 2"	±.008"
2 1/4" × 2 1/4"	±.010"
2 1/2" × 2 1/2"	±.010"
2 3/16" × 2 3/16"	±.010"

Note: Measurements from outside dimensions shall be made at least 2 inches from the end of the tube.

(2) **Wall Thickness Tolerances,** Permissible variation in wall thickness is +.011" – .008".

(3) **Convexity and Concavity.** Measured in the center of the flat sides, tolerance in ±.010", determined at the corner.

(4) **Squareness of Sides and Twist.**

Nominal Outside Dimensions	Squareness Tolerance	Twist Permissible in 3' Length
1 1/2" × 1 1/2"	±.009"	.050"
2" × 2"	±.012"	.062"
2 1/4" × 2 1/4"	±.014"	.062"
2 1/2" × 2 1/2"	±.015"	.075
2 3/16" × 2 3/16"	±.014"	.062"

Note: A sample shall be considered to fail if its sides are not 90° to each other within the squareness tolerance listed above.

(5) **Straight Tolerance.** Permissible variation in straightness is 1/6 of an inch in 3 feet.

(6) **Corner Radii.** Standard outside corner radius shall be 5/32 of an inch ±1/64 inch.

i. **Installation.** The square end of the post shall not be modified or pointed, but shall be capable of being driven into the ground with the use of an approved driving cap.

j. **Slip Base Assembly.** The design and the construction of the slip base assembly shall be as shown on the Plans. The assembly shall be as manufactured by Unistrut Corporation or equal. The manufacturer shall certify that the chemistry, geometry, and mechanical properties are the same as those used in the tests and that the assembly will meet FHWA change-in-volocity requirements.

5. **Flange Channel and Accessories.** Flange channel shall be of the size and shape specified and shall meet the following requirements:

a. **Anchor Plates.** The flange channel and anchor plates shall be rolled from High Strength, Hot-Rolled Steel conforming to ASTM A-499, Grade 60, 60,000 psi minimum yield strength and 90,000 psi minimum ultimate strength.

b. **Safety Retainer-Spacer Strap.** The straps shall be of the size and shape specified and shall be fabricated from steel meeting AISI 1020.

c. **Nuts and Bolts.** The bolts shall be the size specified and shall be fabricated from steel meeting ASTM A-354, Grade BD, case hardened. The nuts shall meet AASHTO M-291, Grade DH, and lockwashers shall be heavy-duty external type. Nuts and bolts shall be cadmium plated ASTM A-165, Type 05, except when using clear chromate.

d. **Fabrication.** The finished post shall be machine straightened and have a uniform finish, free from defects affecting its strength, durability, or appearance. All holes and sheared ends shall be commercially free from burrs.

Sign posts and stringers shall be punched on the center line with 7/16-inch diameter holes on one-inch centers for the entire length.

Base posts shall be punched on center line with a minimum of twelve 7/16-inch diameter holes on one inch centers. The first hole shall be one inch from the top. The bottom of the post shall be pointed for easy installation.

The sign post, base posts, retainer-spacer, and anchor plates shall be galvanized according to AASHTO M-232.

6. **Structural Steel Posts.** Structural steel posts shall be fabricated from material conforming to Section 834.01 A. and shall be galvanized according to Section 854 after fabrication.

894.06 DELINEATORS.

A. **Posts.** Steel posts shall meet ASTM A-702.

Steel posts shall be galvanized according to AASHTO M-111 or be aluminum posts fabricated from aluminum alloy meeting ASTM B-308, Alloy 6061-T6.

Posts shall have holes at one inch spacing the entire length of the post.

B. **Reflectors.**

1. **Reflective Sheeting.** Type III reflective sheeting for delineators shall be white or yellow adhesive coated, permanently adhered to aluminum or galvanized steel.

The reflective sheeting shall meet Section 894.02. Backing material shall meet Section 894.01.

The finished reflector shall show careful workmanship; be free of burrs, scratches, or damaged reflective sheeting; and have essentially a flat surface.

2. **Acrylic Plastic.**

a. **Metal Parts.** The housing shall be .020-inch ASTM B-209 3003-H14 or 5052-0 sheet aluminum formed to approximately 3-1/4 inches in diameter and .235-inch in depth to retain the acrylic reflector. The housing shall be provided with 4 embossed circular reinforcement ribs and marked with the manufacturer's name and part number.

An aluminum grommet with a 3/16-inch inside diameter shall be expanded within the reflector mounting hole.

b. **Acrylic Plastic.** The reflector shall be an acrylic plastic manufactured from methyl methacrylate. The reflector shall consist of a clear and

transparent plastic face, with a minimum of 7 square inches of reflective area, referred to as the lens. It shall have a heat sealable plastic coated metallic foil back fused to the lens under heat and pressure around the entire perimeter of the lens and the central mounting hole to form a unit permanently sealed against dust, water, and water vapor. The reflector shall be colorless, yellow, or red.

The lens shall consist of a smooth front surface free from projection or indentation other than the central mounting hole and identification with a rear surface bearing a prismatic configuration such that it will provide total internal reflection of light.

c. **Optical Requirements**. The optical requirements shall be as follows:

Color	Candelas per Foot-Candle per Square Foot Divergence Angle, –0.1 Degrees Entrance Angle, Deg.	
	0	20
Crystal or Silver	119	47
Yellow	71	28
Red	29	11

The reflex reflector to be tested shall be located 100 feet from a single light source having an effective diameter of 2 inches; the light source shall be operated at approximately normal efficiency. The return light from the reflector shall be measured by a photoelectric photometer having a minimum sensitivity of 1×10^{-7} foot candles per mm scale division. The photometer shall have a receiver aperture of 0.5 inch diameter, shielded to eliminate stray light. The distance from light source center to aperture center shall be 2.1 inches for 0.1° observation angle. During testing, the reflector shall be spun to average the orientation effect. If a test distance other than 100 feet is used, the source and aperture dimensions and the distance between source and aperture shall be modified in the same proportion as the test distance.

Failure to meet the specific intensity minimum shall constitute failure of the reflector being tested; failure of more than 2 reflectors out of 50 subjected to test shall constitute failure of the lot.

d. **Durability.** The durability tests shall be as follows:

(1) **Seal Test.** The following test shall be used to determine if a reflector is adequately sealed against dust and water.

Submerge 50 samples in a water bath at room temperature. Subject the submerged samples to a vacuum of 5 inches for 5 minutes, then examine them for water intake. Failure of more than 2% of the number tested shall be cause for rejection.

(2) **Heat Resistance Test.** Three reflectors shall be tested for 4 hours in a circulating air oven at 175° ± 5°F. The test specimens shall be placed in a horizontal position on a grid or perforated shelf permitting free air circulation. At the conclusion of the test, the samples

shall be removed from the oven and permitted to cool in air to room temperature. The samples, after exposure to heat, shall show no significant change in shape and general appearance when compared with unexposed control standards. No failures will be permitted.

C. **Fasteners.** Aluminum tension pin fasteners shall be an aluminum alloy meeting ASTM B-211 Alloy 2024-T4 or 6061-T6. The collar shall be aluminum alloy meeting ASTM B-211 Alloy 6061-T67 or 6061-T6. The fasteners shall conform to the Contract.

Steel tension pin fasteners shall be a medium carbon steel with a minimum shear strength of 70,000 psi and a minimum tensile strength of 67,500 psi. They shall be galvanized according to AASHTO M-232 conforming to the Contract.

894.07 SAMPLING AND TESTING.

A. **Base Metal.** The Contractor shall furnish to the inspector a certification as specified in Section 801.01.

B. **Solutions for Cleaning and Etching.** The solutions used for cleaning and etching shall not vary more than 10% from the manufacturer's recommendation. In addition, all treatment tanks shall be charged with fresh chemicals at least once a year. Titration equipment shall be available for the inspector's use to check the solution strengths.

C. **Inspection.** All material and finished signs are subject to inspection at the place of manufacture and shall be subject to final inspection at the time of erection. Test panels, 12 inches by 12 inches representative of any stage of production, shall be furnished upon the inspector's request. These panels shall be processed with the regular production run and witnessed by the inspector. All surfaces exposed to weathering shall be free of any defects that may impair the serviceability or detract from the general appearance or color matching of the sign. Signs with any defects or damage that would affect their appearance or serviceability will not be accepted. No repairs shall be made to the face sheet without the approval of the inspector. Signs not conforming in all respects to the requirements will be rejected.

D. **Reflective Sheeting.** The reflective sheeting shall be certified by the manufacturer that the minimum brightness values previously listed for each color, have been met. The color of each type shall be checked by the inspector using the standard color charts as specified.

1. **Reflective Sheeting Flexibility.** The Contractor shall furnish test specimens for each color of reflective sheeting according to AASHTO M-268. Type III and Type IV reflective sheeting shall be applied to a plate as specified in AASHTO M-268 and shall be furnished for each color. These test specimens shall be processed with the regular production run and witnessed by the inspector.

2. **Inspection.** The reflective sheeting packages shall be inspected before installation on sign backings. The Contractor shall provide access by the inspector and shall indicate the roll packages or flat packages to be used on a particular Project. The inspector will mark the roll of flat material and note the manu-

facturer's date. All material used on that Project shall be used within one year of this date. If this date is past on the date of inspection, the roll shall be rejected.

E. **Torque Control Nuts.** The Contractor shall furnish to the inspector a certification, as specified in Section 801.01, if torque control nuts are chosen for use.

894.08 STRUCTURES FOR OVERHEAD SIGNS.

A. **General.** Shop drawings shall be submitted for all structures for overhead signs. Submission shall be according to Section 770.02 B, Volume 2. Welders as specified in 105.06 D.

1. **Welding.**

a. **Welding Steel.** All steel welding shall be done according to the specifications for welding of steel structures in the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

(1) **Treatment of Welded Areas.** The individual components may be galvanized after fabrication according to AASHTO M-11, or each member may be galvanized before fabrication as specified in Sections 894.08 B and C. Areas damaged by welding may be metallized by one of the methods in Sections 894.08 A.1.a.(2) or (3).

When galvanizing after fabrication, the struts and diagonal tubes shall have a 3/4-inch minimum hole punched into chords to facilitate galvanizing. The chords on the capped end shall have two 1/2-inch holes at top and bottom to facilitate galvanizing. The end tower vertical columns shall have two 1/4-inch holes in the base plate and two 3/4 inch holes at the top of each column to facilitate galvanizing.

(2) **Metallizing Process.** The portion of the unit on which the galvanized coating has been damaged shall be thoroughly cleaned by blasting with sharp sand or steel grit. The blasted area shall extend at least 1/2-inch over the undamaged section of galvanized coating. The area shall be coated with zinc within 24 hours after blasting. Should there be a delay of more than 24 hours, or should any of the cleaned portion become soiled before metallizing, these sections shall be reblasted.

Zinc wire containing at least 99.98% zinc shall be used in the metallizing operation. The pure zinc coating applied to the section shall have a thickness of at least 0.005-inch (2.98 oz. per square foot) over the damaged section, and shall taper off to zero thickness at the edge of the blasted undamaged section.

Areas which have not been cleaned or coated satisfactorily shall be rejected. If the Engineer so elects, the metallizing shall be done in the Engineer's presence.

(3) **Paint-on-Galvanizing.** Paint-on-galvanizing shall be applied to areas that have been damaged, in the manner specified by Federal Specification MIL-P-21035.

b. **Welding Aluminum.** All aluminum welding shall be done according to the specifications for welding aluminum structures, in AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

Welding shall be carefully checked by the fabricator by visual inspection of all welds, by proof testing of welds, and by restrictive testing of weld samples fabricated during the production welding.

2. **Grating and Handrail.** The walkway grating and handrail shall be of the type and material shown in the Contract. If grates require splicing, the splice shall be at the center of the support. The rail may be in one or more pieces, depending on length, with a post assembly at each end of each piece of rail.

The aluminum grating shall meet ASTM B-221, Alloy 6061-T6. The aluminum grating shall resist a point load of 500 pounds and shall have a deflection of 1/4-inch or less when loaded with a uniform load of 100 pounds per linear foot. The deflection shall be based on a simple span, 5 feet in length.

The U-bolts, bolts, washers, nuts, and clips shall be austenitic stainless steel.

The aluminum railing shall be composed of 1-1/4-inch nominal diameter Schedule 40 pipe and fittings, with flush surfaces. Joints between the pipe and fittings shall be welded and ground smooth. Railings shall be made in sections of suitable size to be raised or lowered by one man from one end of each section. The railing hinge and locking pin shall be of the type specified.

B. **Free Standing Overhead Signs.**

1. **Round Tubes and Standard Pipe.** Steel round tubes and standard pipe members shall meet AASHTO 270 Grade 36, M-161, or ASTM A-53 (Grade B Steel) and shall be galvanized according to AASHTO M-111.

2. **Round-Tapered or Octagonal-Tapered Tubes.** The overhead sign structure may be designed and fabricated from round-tapered or octagonal-tapered steel tubes in lieu of round and standard pipe as shown in the Contract. Major dimensions shall be retained, such as truss cross section and length, and end towers vertical dimensions. If this option is chosen, the Contractor shall furnish to the Department all necessary calculations and drawings used in designing these structures. The structures shall be designed according to the latest issue of the AASHTO publication of Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. A wind velocity of 85 mph shall be used to compute the wind pressures on the signs and structures. Shop drawings shall be submitted after the above design has been submitted and approved.

The round-tapered or octagonal-tapered tube members shall have a minimum yield strength of 50,000 psi after fabrication. The shaft shall have no more than one longitudinal weld and shall be galvanized according to AASHTO M-111.

3. **Flat Bars.** Flat bar members shall meet AASHTO 270 Grade 36 or M-161 and galvanized according to AASHTO M-111.

4. **Flange.** Flange, base plate, clamps, and plate material shall be the same material used in fabricating columns and truss chords.

5. **Truss.** Steel shapes shall meet AASHTO 270 Grade 36 or M-161 galvanized according to AASHTO M-111.

6. **Hardware.** Steel bolts shall be fabricated according to ASTM A-325, and galvanized according to AASHTO M-232. Steel U-bolts shall be fabricated from round steel bars and threaded on both ends meeting ASTM A-307, and galvanized according to AASHTO M-232.

7. **Anchor Bolts, Nuts, and Washers.** The material used for anchor bolts shall be medium carbon, hot rolled steel bars meeting AASHTO M-314 Grade 55 and the following mechanical requirements:

Yield Strength	55,000 psi
Ultimate Strength	85,000 psi
Elongation (2-inch gage), min	21% *
Reduction in Area, min	30% **
Longitudinal Charpy V-Notch, min	15 ft-lbs at 40°F.

*Elongation (8-inch gage), min 18% for bolts tested full section.
** Bolts over 2 to 2 1/2 in., 22% min; over 2 1/2 to 3 in., 20% min.

Notch toughness tests on specimens shall be performed according to Test Frequency P of ASTM A-673 and the notch shall be oriented perpendicular to the longitudinal axis of the anchor bolt. It may be necessary to heat the steel in order to meet the Charpy V-Notch impact requirements.

Anchor bolts, nuts, and washers shall be zinc-coated, as shown on the plans and specifications, according to ASTM A-153. Dimensions of the bolts shall be as shown on the plans.

Threads on the anchor bolts shall be 8UN series as specified in ANSI B1.1 and shall have Class 2A tolerances before coating. After coating, the maximum limit of pitch and major diameters may exceed the Class 2A limit by 0.021 inch for bolts 1 inch and smaller, and by 0.031 inch for bolts larger than 1 inch in diameter. Anchor bolt threads may be cut or rolled into the round bar stock.

Nuts for anchor bolts shall conform to ASTM A-563, Grade A, heavy hex. The threads shall be 8UN series as specified in ANSI B1.1 Class 2B tolerances, and tapped oversize after coating by not more than 0.021 inch for nuts 1 inch and smaller, or more than 0.031 inch for nuts larger than 1 inch. The nuts shall be lubricated as specified in Supplementary Requirement S1 of ASTM A-563.

Washers shall conform to ASTM F-436 for circular washers.

All bolts shall be furnished with certification, including results of yield strength, tensile strength, elongation, reduction of area, and charpy tests, with

identification to the heat number of the steel, and to furnace lot number if heat treated. Anchor bolts for cantilever and truss sign supports shall have an identification stamped in the end of the hook to identify them to a specific heat number and the threaded end cross section to identify them to a specific test report prior to sampling the bolts for testing.

The Engineer will sample anchor bolts (including nuts and washers) for destructive testing at the following frequency:

Cantilever sign supports – 1 bolt per cantilever per heat.
Truss sign supports – 1 bolt per truss assembly per heat.
Other uses – 1 bolt per heat per project.

Additional bolts shall be ordered for sampling.

C. **Overhead Signs on Bridge Structures.**

1. **Plates.** Brackets and reinforcing plates shall meet ASTM B-209 Alloy 6061-T6.

2. **Angles, I-Beams, and Channels.** Aluminum shapes shall meet ASTM B-308 Alloy 6061-T6.

3. **Bolts, Nuts, Washers, and Lockwashers.** All nuts, bolts, washers, and lockwashers used in the erection and fabrication of the overhead sign structures on bridges shall be austenitic stainless steel; except, the bolts used for the attachment to the bridge shall be fabricated according to ASTM A-325 and galvanized according to AASHTO M-232.